Remarks

1. Applicant acknowledges the correctness of Examiner's amendment of the preliminary amendment.

2. Claim 9 has been corrected as to a format error without any narrowing.

3. 35 U.S.C. §102

4. Claims 1-4 and 12-14 are rejected under 35 U.S.C. § 102 (e) as being anticipated by Zhang et al. Applicant notes that Examiner's citations to Zhang is the reference Pub. No. US 2002/0011335, and applicant notes that U.S. Pat. No. 6,575,248 notes this prior publication. Both these references are in the information disclosure for this application.

Regarding claims 1-4 as well as dependent claims 5-8, Applicant argues that all of these claims are allowable in view of the Zhang references.

The Examiner cites Zhang as teaching "generating gaseous product from the formation." Zhang does not teach generating gaseous products, or any other products from any formation. In fact, the term "formation" never appears in Zhang.

Zhang at Pub. No. `335 paragraph 0065 does state, "the heat generated by the fuel cell may also be used in some downhole environments (as in highly viscous, cool environments…". Clearly Zhang does not teach heating a formation to generate a gaseous product. Zhang does not teach the use of said generated gaseous product as fuel for the fuel cells.

In fact it is not feasible for the fuel cells in Zhang to utilize the gaseous fuels produced from a heated formation as claimed in Claim 1 of the present invention. The fuel cells in Zhang are provided with fuel from a "fuel vessel" US Pat. No. 6,575,248, Fig. 1, Item **12**. Zhang teaches that:

*"... once the one or more fuel cells **730** have exhausted their resources (oxidant and fuel supply) to generate power, or for periodic maintenance, the fuel cells **730** are replaced.*" Alternatively, *"...once the one or more fuel cells **730** have exhausted their resources, or for periodic maintenance, the oxidant reservoirs **734** and the fuel reservoirs **736** are replenished.*" Page 12, line 27 et seq, Zhang does not teach, and it is difficult to imagine, how such replenishment of Zhang's "closed system" fuel cells could be "provided to and used by said fuel cells as fuel" as claimed in Applicant's claim 1.

Zhang does not teach production of gaseous fuel from a hydrocarbon formation. Zhang teaches production of hydrogen by regeneration from by-product water through reaction with metal hydride, all of which takes place within the fuel cell assembly. Pub. No. `335, Fig. 13, and (Par. 60). Therefore, claims 1-8 are neither anticipated or rendered obvious by Zhang.

Examiner rejected claims 12-14 as anticipated by Zhang. Please review Applicant's amended claim 12, wherein the elements of original claim 13 have been added as well as the cooler gas being defined as containing an oxidant, and a heater is added.

Zhang's batch supply vs. Savage's continuous supply:

Zhang's Figure 13 clearly illustrates the fundamental differences between claims 12-14 and Zhang. Figure 13 shows downhole solid oxide fuel cells being supplied with fuel and oxidizer from a "fuel vessel" **602** and an "oxidant vessel" **604**.

Zhang teaches a batch operation of fuel cells, in which vessels containing fuel and oxidant supply the fuel cells until those vessels are exhausted, at which time they are replenished with new supplies or are replaced. At page 12, lines 23 – 49, Zhang teaches replacement or replenishment of said vessels:

"*Depending upon the life of the field, the fuel cells 730 may need to be replaced or replenished periodically. In the embodiment shown in FIG. 17 wherein the one or more fuel cells 730 are located within the manifold power supply housing 702, once the one or more fuel cells 730 have exhausted their resources (oxidant and fuel supply) to generate power, or for periodic maintenance, the fuel cells 730 are replaced. Replacing the fuel cells 730 is accomplished by divers, remote operated vehicles (ROVs), or autonomous underwater vehicles (AUVs), for example.*

In an alternate embodiment shown in FIG. 18, once the one or more fuel cells 730 have exhausted their resources, or for periodic maintenance, the oxidant reservoirs 734 and the fuel reservoirs 736 are replenished. As shown, the oxidant reservoirs 734 are in communication with a supply valve 704 located on the outside of the power supply housing 702. Similarly, the fuel supply reservoirs 736 are in communication with a supply valve 706. Fuel and oxidant from an external source can be provided to the supply valves 704, 706 and, in turn, to the reservoirs 734, 736 as needed. In one embodiment, shown in FIG. 19, the external source of fuel and oxidant is one or more interchangeable bottles/tanks (containers) 740. The bottles/tanks 740 can either be

replaced or replenished when their supply has been exhausted. Again, such replenishing or replacement can be accomplished by divers, ROVs, or AUVs, for example."

By contrast, claims 12-14 describe downhole fuel cells that are continuously supplied with oxidant from the surface. The fuel may be supplied continuously from the hydrocarbon formation in which the fuel cells are installed and which fuel is liberated from the formation by the action of heat originating from the fuel cells, thus creating a self-fueling and continuous process. The oxidant is either air, supplied continuously from the atmosphere, or a concentrated flow of oxygen also produced continuously from the atmosphere. See applicant's amended claim 12.

Zhang's closed exhaust architecture vs. Savage's open exhaust

A close examination of Zhang's Fig. 13 also shows that there is no exhaust conduit. There is a fuel conduit **618**, "fuel stream", and an oxidant conduit, not numbered, but there is no exhaust conduit. Instead Zhang shows a "water vessel" **614**, containing metal hydride **616**, which reacts with the water to produce hydrogen which is then supplied, possibly by pump **622**, back to the fuel conduit **618**. There is no provision in Zhang for the exit of warm exhaust from the fuel cells. In Fig. 13 Zhang shows a closed, recirculating fuel cell architecture.

By contrast, claims 12-14 teach the continuous removal of hot exhaust from the fuel cells, through dedicated exhaust conduits, and further teaches the use of said exhaust to heat the surrounding formation and to preheat incoming air.

Zhang's insulated fuel cells vs. Savage's thermally coupled fuel cells

Zhang's Fig. 13 does not show thermal insulation. However, Zhang teaches the insulation of fuel cells to thermally isolate the cells from the surrounding formation.
At page 8, line 25 – 28, Zhang teaches:

"Of course thermal insulation will be needed with a solid oxide fuel cell to protect the equipment and surrounding environment and to maintain the high temperature within the fuel cell required for its use."

And at page 8, lines 57 – 62:

"The solid oxide fuel cell can operate with internal temperatures ranging from about 650.degree. C. to over 1,000.degree. C. and with the proper insulation can operate within environments that includes the temperature range of 0.degree. to 1,000.degree. C. which would cover almost any wellbore environment."

By contrast, claims 12-14 teach downhole fuel cells that are constructed specifically to match the thermal absorption characteristics of the formation in which they are to be installed. They also teach the thermal coupling of the fuel cells to the surrounding casing and the formation, thereby conducting heat from the fuel cells into the formation.

This is exactly the opposite of Zhang, which teaches thermal isolation of solid oxide fuel cells from the surrounding formation with insulation.

Examiner rejects claims 1-45 as anticipated by U.S. Pat. No. 6,581,684 (Shell).

First and foremost, Shell does not teach the use of fuel cells as downhole formation heaters. The Shell patent, US Patent 6,581,684, refers to numerous forms of downhole "heat sources", but fuel cells are never among them. The Shell patent also frequently refers to fuel cells, but only as part of "surface facilities", never as downhole heaters.

The Examiner cites number **100** from the Shell patent, which appears in Figure 3 and designates "heat sources". The Shell patent defines "heat source" on P. 24, L. 60, as:

"any system configured to provide heat to at least a portion of a formation. For example, a heat source may include electrical heaters such as an insulated conductor, an elongated member, and a conductor disposed within a conduit, as described in embodiments herein. A heat source may also include heat sources that generate heat by burning a fuel external to or within a formation such as surface burners, flameless distributed combustors, and natural distributed combustors, as described in embodiments herein. In addition, it is envisioned that in some embodiments heat provided to or generated in one or more heat sources may by supplied by other sources of energy. The other sources of energy may directly heat a formation, or the energy may be applied to a transfer media that directly or indirectly heats the formation. It is to be understood that one or more heat sources that are applying heat to a formation may use different sources of energy. Thus, for example, for a given formation some heat sources may supply heat from electric resistance heaters, some heat sources may provide heat from combustion, and some heat sources may provide heat from one or more other energy sources (e.g., chemical reactions, solar energy,

wind energy, or other sources of renewable energy). A chemical reaction may include an exothermic reaction such as, but not limited to, an oxidation reaction that may take place in at least a portion of a formation. A heat source may also include a heater that may be configured to provide heat to a zone proximate to and/or surrounding a heating location such as a heater well. Heaters may be, but are not limited to, electric heaters, burners, and natural distributed combustors."

This general description of heat sources by Shell cannot anticipate all novel forms of heat sources, including fuel cells, which would be patentable improvements to the art. Geothermic fuel cells are clearly a novel heat source and an improvement to the art taught by Shell. The Shell patent does not, as implied by the Examiner, include fuel cells as a heat source.

Under the detailed description of Figure 3 on page 35, Line 9, heat sources **100** are described as follows:

"*Heat sources 100 may include, for example, electrical heaters such as insulated conductors, conductor-in-conduit heaters, surface burners, flameless distributed combustors, and/or natural distributed combustors. Heat sources 100 may also include other types of heaters.*"

What Shell anticipates is any kind of heat source to apply heat to a hydrocarbon formation in accordance with the method taught for "In Situ Thermal Processing". Patent 6,581,684 is about a method of heating, not a type of heater. It does not preclude patents on any type of heater, much less a geothermic fuel cell type heater.

The references to fuel cells in the Shell patent are specifically and repeatedly with regard to energy or electric power production in a generation unit as part of a <u>surface facility</u>. For example at page 16:

" *Certain embodiments may include separating a <u>fuel cell</u> feed stream from fluids produced from pyrolysis of at least some of the hydrocarbons within a formation. The <u>fuel cell</u> feed stream may include H.sub.2, hydrocarbons, and/or carbon monoxide. In addition, certain embodiments may include directing the <u>fuel cell</u> feed stream to a <u>fuel cell</u> to produce electricity. The electricity generated from the synthesis gas or the pyrolyzation fluids in the <u>fuel cell</u> may be configured <u>to power electrical heaters</u>, which may be configured to heat at least a portion of the formation.* "

Thus, in her reference to Figure 3, the examiner should have referred to number **108 treatment facilities**, not number **100 heat sources**. Under the detailed description of Figure 3 (Pg. 35, Ls. 37-40), number **108** is described as: "*The treatment facilities **108** may include separation units, reaction units, upgrading units, <u>fuel cells</u>, turbines, storage vessels, and other systems and units for processing produced formation fluids.*"

Figure 33 shows that the Shell patent only contemplates fuel cells as part of the surface facilities including an "energy generation unit". (Pg. 103, Ls. 48-62):

"*In one embodiment, produced synthesis gas 918 may be used for production of energy. In FIG. 33, treated gases 920 may be routed from treatment section 900 to **energy generation unit 902** for extraction of useful energy. Energy may be extracted from the combustible gases generally by oxidizing the gases to produce heat and converting a portion of the heat into mechanical and/or electrical energy. Alternatively, **energy generation unit 902** may include a <u>fuel cell that produces electrical energy</u>. In addition, energy generation unit 902 may include, for example, a molten carbonate fuel cell or another type of fuel cell, a turbine, a boiler firebox, or a downhole gas heater. Produced electrical energy 904 may be supplied to power grid 906. A portion of the produced electricity 908 may be used to supply energy **to electrical heating elements 910** that heat formation 912.*

This distinction is particularly emphasized at Figure 34 (Pg. 105, Ls 14-31), which is devoted specifically to the application of fuel cells to the Shell patent:

"*FIG. 34 illustrates an embodiment in which fluid produced from pyrolysis may be separated into a fuel cell feed stream and fed into a fuel cell to produce electricity. The embodiment may include carbon containing formation 940 with producing well 942 configured to produce synthesis gas and heater well 944 **with electric heater 946** configured to produced pyrolysis fluid 948. In one embodiment, pyrolysis fluid may include H.sub.2 and hydrocarbons with carbon numbers less than 5. Pyrolysis fluid 948 produced from heater well 944 may be fed to gas membrane separation system 950 to separate H.sub.2 and hydrocarbons with carbon numbers less than 5. **Fuel cell feed stream 952**, which may be substantially composed of H.sub.2, may be fed **into fuel cell 954**. Air feed stream 956 may be fed into fuel cell 954. Nitrogen stream 958 may be vented from fuel cell 954. Electricity 960 produced from the fuel cell may be routed to a power grid. **Electricity 962** may also be used to power **electric heaters 946** in **heater wells 944**.*"

As shown by the description of Fig. 34, **fuel cells 954**, are part of the surface facilities and completely distinct from the down-hole heat source, **electric heaters 946.**

Other figures teach the same use of fuel cells as part of a surface facility where the processed fuel from the formation is used to produce electricity. The further teaching in Figure 35, shows steam from a fuel cell used to produce synthesis gas. This is still wholly distinct from using the fuel cell as a heater, and reinforces the teaching, universal in the patent, that the fuel cells are part of the surface facilities:

"*FIG. 35 depicts an embodiment of a synthesis gas generating process from hydrocarbon containing formation 976 with flameless distributed combustor 996. Synthesis gas 980 produced from production well 978 may be fed into gas separation plant 984 where carbon dioxide 986 may be separated from synthesis gas 980. First portion 990 of carbon dioxide may be routed to a formation for sequestration. Second portion 992 of carbon dioxide may also be injected into the formation with synthesis gas generating fluid. Portion 993 of synthesis gas 988 may be fed to heater well 994 for combustion in distributed burner 996 to produce heat for the formation.* ***Portion 998 of synthesis gas 988*** *may be fed to* ***fuel cell 1000*** *for the production of electricity. Electricity 1002 may be routed to a power grid.* ***Steam 1004*** *produced in the fuel cell and steam 1006 produced from combustion in the distributed burner may be fed to the formation for generation of synthesis gas.*"

Figure 71 is a schematic devoted solely to **surface facilities**, in which the fuel cells are explicitly part of the surface facilities and used to create electricity with processed fuel from the formation:

The **surface facilities 2800** "*may be configured such that first portion 2820 of stream 2818 may flow from gas treatment unit 2810 to* ***power generation unit 2822****. … The power generation unit may also include, for example, a molten carbonate fuel cell, a solid oxide fuel cell, or other type of fuel cell. The facilities may be further configured such that the extracted useable energy may be provided to user 2824. User 2824 may include, for example, surface facilities 2800, a heat source disposed within a formation, and/or a consumer of useable energy.*"

Figure 71 clearly differentiates between surface facilities 2800 and heat sources in the formation.

Figure 73 reinforces fuel cells as a component of the surface facilities:

"*FIG. 73 illustrates an embodiment of an additional processing unit that may be included in surface facilities 2800 such as the facilities depicted in FIG. 71. ... Furthermore, produced synthesis gas 2907 may be provided to process unit 2922 for production of ammonia and/or urea 2924, and <u>fuel cell 2926</u> that may be configured to produce <u>electricity 2928</u>.*"

The Examiner cites **562** of the Shell patent as her reason for rejecting the apparatus claims of the present invention. **562** appears on Fig. 16 of the Shell patent and shows an "insulated conductor heater" a type of <u>electrical resistance heater</u> which has nothing in common with a geothermic fuel cell heater except the casing, **577**, and the fact that they are both round.

References in the Shell patent to other patents refer only to the use of fuel cells as a source of electricity:

U.S. Pat. No. 4,250,230 to Terry, "*describes a system for in situ gasification of coal. A subterranean coal seam is burned from a first well towards a production well. Methane, hydrocarbons, H.sub.2, CO, and other fluids may be removed from the formation through the production well. The H.sub.2 and CO may be separated from the remaining fluid. The H.sub.2 and CO may be sent to <u>fuel cells to generate electricity</u>.*"

U.S. Pat. No. 5,554,453 to Steinfeld et al., describes " *an ex situ coal gasifier that supplies fuel gas to a fuel cell. <u>The fuel cell produces electricity</u>.*"

All other references to fuel cells in the patent are specific to the use of the fuel cells to process synthesis gas or other recovered fuels to produce electricity. No reference is made to the use of fuel cells to produce heat:

"*Synthesis gas may also be used for other purposes. Synthesis gas may be combusted as fuel. Synthesis gas may also be used for synthesizing a wide range of organic and/or inorganic compounds such as hydrocarbons and ammonia. Synthesis gas may be used to generate electricity, by combusting it as a fuel, by reducing the pressure of the synthesis gas in turbines, and/or using the temperature of the synthesis gas to make steam (and then run turbines). Synthesis gas may also be used in an energy generation unit such as a molten carbonate fuel cell, a solid oxide fuel cell, or other type of fuel cell.*"

"*Certain embodiments may include separating a fuel cell feed stream from fluids produced from pyrolysis of at least some of the hydrocarbons within a formation. The fuel cell feed stream may include H.sub.2, hydrocarbons, and/or carbon monoxide. In addition, certain embodiments may include directing the fuel cell feed stream to a fuel cell to produce electricity. The electricity generated from the synthesis gas or the pyrolyzation fluids in the fuel cell may be configured to power electrical heaters, which may be configured to heat at least a portion of the formation. Certain embodiments may include separating carbon dioxide from a fluid exiting the fuel cell. Carbon dioxide produced from a fuel cell or a formation may be used for a variety of purposes.*"

"*The non-condensable hydrocarbons of fluid produced from a hydrocarbon containing formation may have a H.sub.2 content of greater than about 5% by weight, greater than about 10% by weight, or even greater than about 15% by weight. The H.sub.2 may be used, for example, as a fuel for a fuel cell, to hydrogenate hydrocarbon fluids in situ, and/or to hydrogenate hydrocarbon fluids ex situ.*"

"*A mixture of steam and oxygen, or steam and air, may be substantially continuously injected into a formation. If injection of steam and oxygen is used for synthesis gas production, the oxygen may be produced on site by electrolysis of water utilizing direct current output of a fuel cell.*"

"*In one embodiment, fluid produced from pyrolysis of at least some hydrocarbons in a formation may be fed into a reformer to produce synthesis gas. <u>The synthesis gas may be fed into a fuel cell to produce electricity</u>. In addition, carbon dioxide generated by the fuel cell may be sequestered to reduce an amount of emissions generated by the process.*"

"*In addition, hydrocarbon fluids, such as pyrolysis fluids, may be pre-processed prior to being fed to a reformer. The reformer may be configured to transform the pyrolysis fluids into simpler reactants prior to introduction to a fuel cell. For example, pyrolysis fluids may be pre-processed in a desulfurization unit. Subsequent to pre-processing, the pyrolysis fluids may be provided to a reformer and a shift reactor to produce a suitable fuel stock for a H.sub.2 fueled fuel cell.*"

"*The synthesis gas produced by the reformer may include any of the components described above, such as methane. The produced synthesis gas 1070 may be fed to **fuel cell 1072**. A portion of **electricity 1074** <u>produced by the fuel cell</u> may be sent to a power grid. In addition, a portion of **electricity 1076** may be <u>used to power **electric heater 1064**</u>. Carbon dioxide 1078 exiting the fuel cell may be routed to sequestration area 1080.*"

The Shell patent is very consistent in its references to fuel cells as part of the surface facilities, mostly as a way to produce electricity. The Shell patent never anticipates the use of fuel cells as an in situ heat source.

The Examiner's reference to "Fuel Cells 100" is in error. **100** in the Shell patent refers to "heat sources" and as we have shown above, there is no correspondence between heat sources and fuel cells in the Shell patent. In Figs. 1&2 of the present invention, **100** does indeed refer to fuel cells.

The Shell patent is primarily a method patent, but it does teach specifics in regard to certain types of in-situ heaters.

The Shell patent teaches specifics with regard to:

1 - "natural distributed combustor" (Pg. 45, L. 59 through Pg. 52, L. 45; Figs. 10 -14).

2 - "electric heater **510**" or "insulated conductor heater **562**" or "conductor in conduit" heater **580**, **582** or "elongated members" or "bare metal heaters" (Pg.52, L. 46 through Pg. 73, L. 54; Figs. 15 – 25), all of which are variations on electrical resistance heaters. Note that the Examiner cites 562 as part of her basis for rejection of our claims. She labels 562 as "formation/conduction/conductive heater". There is no such language in the Shell patent. I think she may be confused between electrical conduction and thermal conduction. In the Shell patent, 562 is referring to an insulated electrical conductor **575**, see Fig. 16. It is a completely different heater type than a geothermic fuel cell heater.

3 - "surface combustor" (Pg. 73, L. 55 through Pg. 74, L. 61; Figs. 26&27) which is a burner at the surface injecting hot exhaust into a borehole, together with combinations of surface burners and down-hole resistance heaters.

4 – "flameless combustors" (Pg 74, L. 62 through Pg. 75, L. 53; Fig. 28).

Shell does not teach fuel cell heaters, <u>and</u> does not teach the present invention's improvements to fuel cell heaters.

Wherefore, Applicant respectfully requests withdrawal of any rejections based on the Shell patent. Applicant requests passage to allowance of all claims.

Respectfully submitted,

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